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PHILOSOPHICAL TRANSACTIONS.

XIII. *On a new phenomenon of electro-magnetism.* By Sir HUMPHRY DAVY, *Bart. Pres. R. S.*

Read March 6, 1823.

ON a subject so obscure as electro-magnetism, and connected by analogies more or less distinct with the doctrines of heat, light, electricity, and chemical attraction, it is not difficult to frame *hypotheses*; but the science is in a state too near its infancy to expect the developement of any satisfactory *theory*; and its progress can only be ensured by new facts and experiments, which may prepare the way for extensive and general reasonings upon its principles. Influenced by this opinion, I am induced to lay before the Society an account of an electro-magnetic phenomenon I observed about fifteen months ago in the laboratory of the Royal Institution, and which I have lately had an occasion of witnessing in a more perfect manner, through the kindness of Mr. PEPYS, by the use of a large battery, constructed under his directions for the London Institution, and containing a pair of

plates of about two hundred square feet. In describing this phenomenon, I shall not enter into very minute details, because the experiments, which led to the discovery of it, are very simple, and, though more distinct with a large apparatus, yet it may be observed by the use of a pair of plates containing from ten to fifteen square feet.

Immediately after Mr. FARADAY had published his ingenious experiments on electro-magnetic rotation, I was induced to try the action of a magnet on mercury connected in the electrical circuit, hoping that, in this case, as there was no mechanical suspension of the conductor, the appearances would be exhibited in their most simple form ; and I found that when two wires were placed in a basin of mercury perpendicular to the surface, and in the voltaic circuit of a battery with large plates ; and the pole of a powerful magnet held either above or below the wires, the mercury immediately began to revolve round the wire as an axis, according to the common circumstances of electro-magnetic rotation, and with a velocity exceedingly increased when the *opposite* poles of two magnets were used, one above, the other below.

Masses of mercury of several inches in diameter were set in motion, and made to revolve in this manner, whenever the pole of the magnet was held near the perpendicular of the wire ; but when the pole was held above the mercury between the two wires, the circular motion ceased ; and currents took place in the mercury in opposite directions, one to the right, and the other to the left of the magnet. These circumstances, and various others which it would be tedious to detail, induced me to believe that the passage of the electricity through the mercury produced motions independent of

the action of the magnet ; and that the appearances which I have described were owing to a composition of forces.

I endeavoured to ascertain the existence of these motions in the mercury, by covering its surface with weak acids ; and diffusing over it finely divided matter, such as the seeds of lycopodium, white oxide of mercury, &c. but without any distinct result. It then occurred to me, that from the position of the wires, currents, if they existed, must occur chiefly in the lower, and not the upper surface of the mercury : and I consequently inverted the form of the experiment. I had two copper wires, of about one-sixth of an inch in diameter, the extremities of which were flat and carefully polished, passed through two holes three inches apart in the bottom of a glass basin, and perpendicular to it ; they were cemented into the basin, and made non-conductors by sealing-wax, except at their polished ends ; the basin was then filled with mercury, which stood about a tenth or twelfth of an inch above the wires. The wires were now placed in a powerful voltaic circuit. The moment the contacts were made, *the phenomenon*, which is the principal object of this paper, occurred : the mercury was immediately seen in violent agitation ; its surface became elevated into a small cone above each of the wires ; waves flowed off in all directions from these cones ; and the only point of rest was apparently where they met in the centre of the mercury between the two wires. On holding the pole of a powerful bar magnet at a considerable distance (some inches) above one of the cones, its apex was diminished and its base extended : by lowering the pole further, these effects were still further increased, and the undulations were feebler. At a smaller distance the surface of the mercury

became plane ; and rotation slowly began round the wire. As the magnet approached, the rotation became more rapid, and when it was about half an inch above the mercury, a great depression of it was observed above the wire, and a vortex, which reached almost to the surface of the wire.

In the first experiments which I made, the conical elevations or fountains of mercury were about the tenth or twelfth of an inch high, and the vortices apparently as low ; but in the experiments made at the London Institution, the mercury being much higher above the wire, the elevations and depressions were much more considerable, amounting to the fifth or sixth of an inch. Of course, the rotation took place with either pole of a magnet or either wire, or both together, according to the well known circumstances which determine these effects.

To ascertain whether the communication of heat diminishing the specific gravity of the mercury, had any share in these phenomena, I placed a delicate thermometer above one of the wires in the mercury, but there was no immediate elevation of temperature ; the heat of the mercury gradually increased, as did that of the wires ; but this increase was similar in every part of the circuit. I proved the same thing more distinctly, by making the whole apparatus a *thermometer* terminating in a fine tube filled with mercury. At the first instant that the mercury became electro-magnetic, there was no increase of its volume.

This phenomenon cannot be attributed to common electrical repulsion ; for in the electro-magnetic circuit, similar electrified conductors do not repel, but attract each other ; and it is in the case in which conductors in *opposite* states are

brought near each other on surfaces of mercury, that repulsion takes place.

Nor can the effect be referred to that kind of action which occurs when electricity passes from good into bad conductors, as in the phenomena of points electrified in air, as the following facts seem to prove. Steel wires were substituted for copper wires, and the appearances were the same in kind, and only less in degree ; without doubt, in consequence of a smaller quantity of electricity passing through the steel wires : and by comparing the conducting powers of equal cylinders of mercury and steel in glass tubes, by ascertaining the quantity of iron filings they attracted, it was found that the conducting powers of mercury were higher than those of steel ; the first metal taking up fifty-eight grains of iron filings, and the second only thirty-seven.

Again ; fused tin was substituted for mercury in a porcelain vessel into which wires of copper and steel were alternately ground and fixed : the elevations were produced as in the mercury, and the phenomena of rotation by the magnet ; and it was found by direct experiment, that the conducting powers of the tin, at and just before its point of fusion, did not perceptibly differ, and that they were much higher than those of mercury. Lastly, the communication was made from the battery by two tubes having nearly the same diameter as the wires, filled with mercury, so that the electricity, for some inches before it entered the basin, passed through mercury ; and still the appearances continued the same.

From the rapidity of the undulations round the points of the cones, I thought they would put in motion any light bodies placed above the mercury ; but I could not produce

the slightest motion in a very light wheel hung on an axle ; and when fine powders of any kind were strewed upon the surface, they merely underwent undulations, without any other change of place ; and fine iron filings strewed on the top of the cone, arranged themselves in right lines at right angles to the line joining the two wires, and remained stationary, even on the centre of the cone. The effect, therefore, is of a novel kind, and in one respect seems analogous to that of the tides. It would appear as if the passage of the electricity diminished the action of gravity on the mercury. And that there is no change of volume of the whole mass of the mercury appears from the experiment, page 156 ; and this was shown likewise by enclosing the apparatus in a kind of manometer, terminating in a fine tube containing air enclosed by oil ; and which, by its expansion or contraction, would have shown the slightest change of volume in the mercury : none however took place when the contacts were alternately made and broken, unless the circuit was uninterrupted for a sufficient time to communicate sensible heat to the mercury.

This phenomenon, in which the same effects are produced at the two opposite poles, seems strongly opposed to the idea of the electro-magnetic results being produced by the transition currents or motions of a single imponderable fluid.

On the conjectural part of the subject I shall not however enter, for the reasons stated in the beginning of this paper ; but I cannot with propriety conclude, without mentioning a circumstance in the history of the progress of electro-magnetism, which, though well known to many Fellows of this Society, has, I believe, never been made public, namely, that we owe to the sagacity of Dr. WOLLASTON, the first idea of

the possibility of the rotations of the electro-magnetic wire round its axis, by the approach of a magnet ; and I witnessed, early in 1821, an unsuccessful experiment which he made to produce the effect in the laboratory of the Royal Institution.